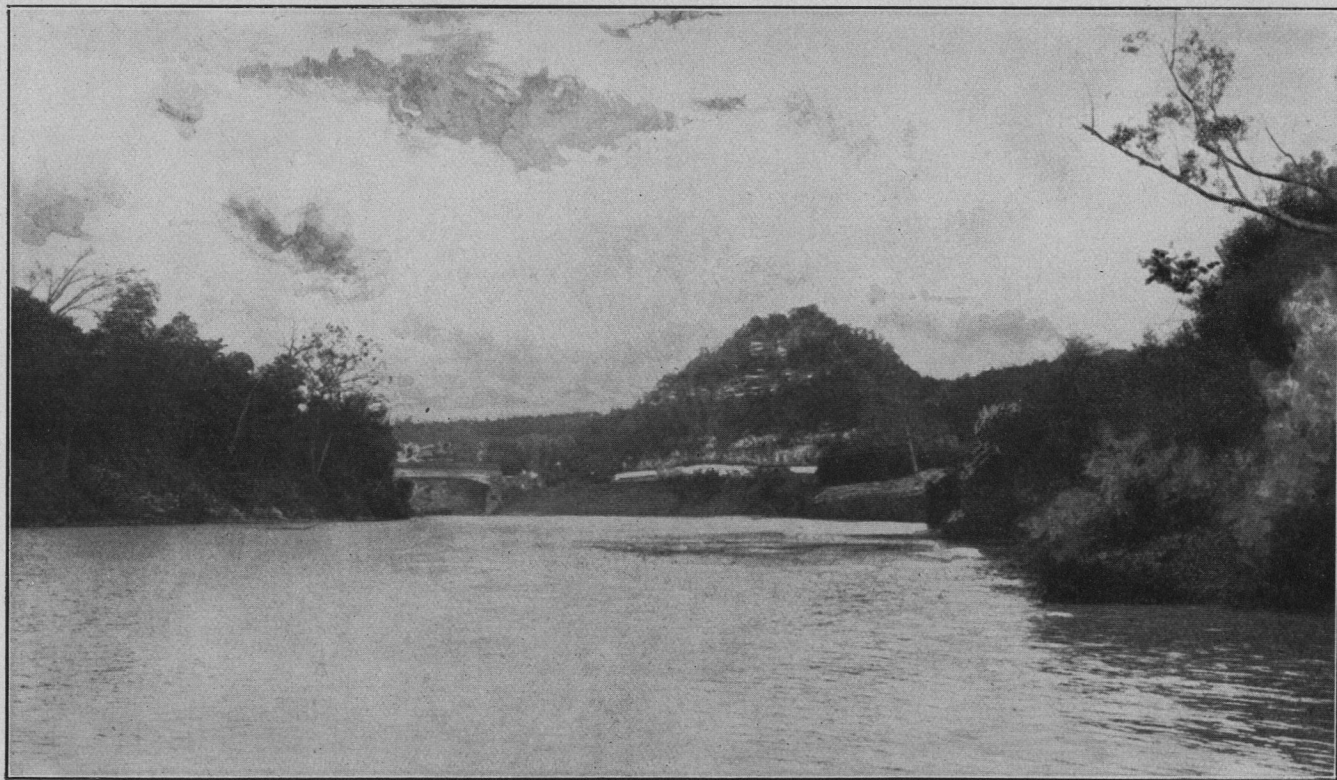


Kentucky Geological Survey.

Bulletin No. 2.

THE LEAD AND ZINC BEARING ROCKS
OF CENTRAL KENTUCKY.

1905.



Boone's Knoll, Formed of Camp Nelson Limestone, Just West of Kentucky River Fault, Mouth of Hickman Creek.

KENTUCKY GEOLOGICAL SURVEY,

CHARLES J. NORWOOD, DIRECTOR.

BULLETIN No. 2.

THE LEAD AND ZINC BEARING ROCKS

OF

CENTRAL KENTUCKY,

WITH

Notes on the Mineral Veins.

BY

ARTHUR M. MILLER.

OFFICE OF THE SURVEY: LEXINGTON, KY.

1905.

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1905.

LETTER OF TRANSMITTAL.

His Excellency, J. C. W. BECKHAM,
Governor of Kentucky.

SIR:—I have the honor to transmit herewith, for publication, a report on the Lead and Zinc Bearing Rocks of Central Kentucky, prepared by Prof. A. M. Miller, assistant geologist. The chief purpose of this report is to describe the strata in which the veins occur, and to present a classification of certain of the Kentucky representatives of the Ordovician formation (commonly known as Lower Silurian) which will be in accord with the classification now generally adopted by geologists. A proper classification of the rocks of the State is necessary for an intelligent study of the mineral deposits. In this report, Prof. Miller has considered only the lower (Mohawkian) portion of the Ordovician rocks. In a report now in course of preparation, Prof. A. F. Foerste will present a classification of the upper (Cincinnatian) portion, hitherto known in the Kentucky reports as the "Hudson."

A report dealing more in detail with the veins themselves will appear in a succeeding bulletin. Another season of field work is required before it can be prepared. It may be said now, however, that enough has already been determined to warrant the statement that the Central Kentucky veins are of greater value—that they reach to greater depth (being continuous from the top of the Trenton down into the Camp Nelson, or "Chazy"); have greater longitudinal extent; are more frequently of good, workable width, and that they carry larger percentages of galena and sphalerite at many points,—than has hitherto been supposed.

Very respectfully,

CHARLES J. NORWOOD,
State Geologist.

LEXINGTON, KY., Dec. 6, 1904.

PROF. C. J. NORWOOD,

Director Kentucky Geological Survey.

DEAR SIR:—I have the honor to transmit to you the accompanying report on the Lead and Zinc Bearing Rocks of Central Kentucky, with Notes on the Mineral Veins. In doing so, I desire to express my indebtedness to Messrs. W. F. Pate, J. H. Gardner, C. R. Gilmour, W. C. Payne and S. A. Denny for valuable assistance in collecting some of the data used in preparing the report.

Very respectfully,

ARTHUR M. MILLER.

I.

THE CINCINNATI GEANTICLINE.

The only formation in Kentucky besides the Lower Carboniferous of the south and western portions of the State which is likely to yield vein ores of economic importance is the Ordovician or Lower Silurian of Central Kentucky; and it would appear that it is only in the lower 550 feet of this series as they are exposed on the top and flanks of a great earth dome, that the outcrops of veins containing such ores are to be looked for.

This "earth dome" is the Central Kentucky culmination of the great "Cincinnati Anticline," an uplift in the form of an arch, the axis of which was formerly supposed to pass through Cincinnati. We now know that it crosses the Ohio river east of this point.

On account of the great extent of this arch (in length from the latitude of Middle Ohio and Indiana to that of Middle Tennessee, and in width something like 100 miles) it is properly termed a "geanticline," a word meaning "earth anticline."

This Cincinnati Geanticline has two points of culmination, one in Jessamine county, Kentucky, and the other in Rutherford county, Tennessee. These may, therefore, be properly termed the Jessamine and Rutherford Domes, respectively. Dome structures especially invite erosion and when of considerable age become greatly truncated, exposing strata originally deep seated. This is the way with the Jessamine Dome of the Cincinnati Geanticline. The lowest strata geologically

exposed in the State are found at the base of the Kentucky river cliffs, where it trenches across this geanticline at a point not far from the apex of the dome. Passing outward from this apex as a center, there is a dip of the strata in every direction, but it is much steeper to the south and southwest, and the uniformity in that direction is much interfered with by a pronounced fault. To the northeast, north and northwest the influence of this dome structure may be traced by the rock dips far beyond the limits of the State.

The first 1,200 to 1,300 feet of strata that are exposed in Northern Kentucky as the result of the erosion of this Jessamine Dome belong to that division of geologic time known as Lower Silurian or Ordovician. In outcrop they constitute an area 8,000 square miles in extent. The counties which include this area lie north of a sinuous line passing through the counties of Lewis, Mason, Fleming, Bath, Montgomery, Clark, Madison, Garrard, Lincoln, Boyle, Marion, Nelson, Bullitt and Jefferson.

A smaller Ordovician area lies in the southern part of the State, along the immediate valley of the Cumberland river from a little below Mill Springs to the Tennessee line. It is a part of the Tennessee Rutherford Dome area. It is included in the counties of Russell, Wayne, Cumberland, Clinton and Monroe, and contains only seventy-nine square miles.

The finest lands agriculturally in the State are bedded upon Ordovician rock. This results both from the character of the rocks composing the Ordovician (they are mainly limestones running relatively high in phosphates) and the great amount of denudation to which they have been subjected. We have here the products of residual decay from a great mass of limestones.

As the result both of dome structure and the great length of time during which these two portions of the uplift have been exposed to atmospheric agencies, they have experienced a vast amount of denudation. It would appear that something

of an anticlinal or arch structure was developed in this region even before the Carboniferous period, and that at times a crest was exposed above the sea.

Since Carboniferous time, the geanticline, with a large amount of contiguous territory in the Eastern United States, has been continuously above the sea and its denudation has been accomplished with varying degrees of rapidity, depending upon its height with reference to sea level.

It is difficult to estimate precisely just what formations above the Ordovician have been removed from over the summit of this arch. It seems certain, however, that rocks up to and including some of the Silurian (Upper Silurian) have been removed, and there is a strong probability that Devonian and Lower Carboniferous once stretched across. Possibly even the Upper Carboniferous once went over.

Taking the case of the Jessamine Dome: The main evidence upon which such conclusions are based are the finding of outliers of the newer formations far up upon its flanks and even on the crest. In every case yet examined by the writer, these outliers mark the place of maximum slip in faults. At these places the faults are double—that is, the later formations are mortised down in the older by fault blocks. The displacements are moderate, not exceeding 300 feet.

As the result of such faulting in southern Fayette and northern Jessamine county, a mass of clay with interbedded limestone and sandstone of Eden (Utica?) age has been mortised down into a rather pure limestone of Upper Lexington (Trenton) age. This Fault Block Strip—the West Hickman—is about fourteen miles long by one-eighth to a quarter of a mile wide. It forms a strip of relatively poor land in the midst of the finest bluegrass.

In the same way, in north Franklin county, two miles southeast of Peak's Mill and one mile east of Elkhorn Creek, a small outlier of Lorraine is preserved, surrounded by Eden. These outliers are well up toward the summit of the dome.

In Shelby county are a group of hills known as Jephtha Knobs, where Silurian strata with the waste of something higher have been preserved. A restoration of the "air lines" of these beds would carry them over the Bluegrass. According to Linney, there are evidences of faulting at the base of these knobs. Burdett's Knob in Garrard county, only eight miles south of the apex of the dome, near Camp Nelson, and with evidences of faulting in the neighborhood, exhibits in succession from base to summit all the strata from top of Ordovician to base of Lower Carboniferous, except the Silurian, here wanting on account of erosion before deposition of the Devonian. This knob has actually upon its summit a few square feet of Waverly Sandstone.

The very arrangement of the beds in concentric bands, with their marginal escarpments facing inwards towards the central dome, and each fringed within by outliers of the same age, would make it appear that outlier and band were once continuous and covered the whole of the dome. Very naturally these beds wore through first at the summit and their inner edges then retreated outward from this as a center in ever-widening concentric circles. The width of the outcrop of the beds represented by colored bands upon the geological map, depends upon two factors—*hardness* and *thickness*; the *harder* the strata, the *narrower* the band and the more *pronounced* the escarpment; the *thicker* the strata, the *wider* the band.

II.

SUBDIVISIONS OF THE ORDOVICIAN.

The following table shows the subdivisions of the Ordovician in Kentucky, according to the latest determinations:

Ordovician.

Table of Formations for Kentucky.

System		Series	Stage	Sub-stage	Feet	Description and Characteristic Fossil
Ordovician	CINCINNATIAN	Richmond	Work on	subdivision	in	Kentucky not Completed.
		Lorraine	Work on	subdivision	in	Kentucky not Completed.
		Utica, in part	Eden	Garrard	65	Finegrained sandstone in Central Kentucky. Middle layers concretionary. Northward S. S. wanting at this horizon.
					200	Alternating blue shale and thin limestone. Shale appearing as clay in outcrop. Limestone often crinoidal and wave marked. <i>Dalmanella multisecta</i> .
	MOHAWKIAN	Trenton	Lexington	Winchester	40	Northward not differentiated. Blue and gray "knotty" limestone with some shale in Central Kentucky. <i>Cyclonema varicosum</i> .
				Bigby	75	Gray crystalline limestone, very phosphatic and cherty toward top in Central Kentucky. <i>Hebertella borealis</i> .
				Hermitage	125	Gray crystalline limestone with some shale. <i>Prasopora simulatrix</i> .
				Logana	10	Argillaceous limestone and shale. <i>Modiolidon oviformis</i> .
				Curdsville	30	Cherty, crystalline limestone. <i>Dinorthis pectinella</i> .
		Stone's River	Highbridge	Tyrone	90	Light and dove colored limestone: compact with conchoidal fracture exhibiting facets of calcite; "birds-eye" limestone. <i>Helicotoma verticalis</i> .
				Oregon	25	Magnesian limestone in two beds.
				Camp-nelson	285	Massive compact limestone; fracture conchoidal. <i>Macluria bigbyi</i> .

Stone's River (Highbridge of Campbell.)

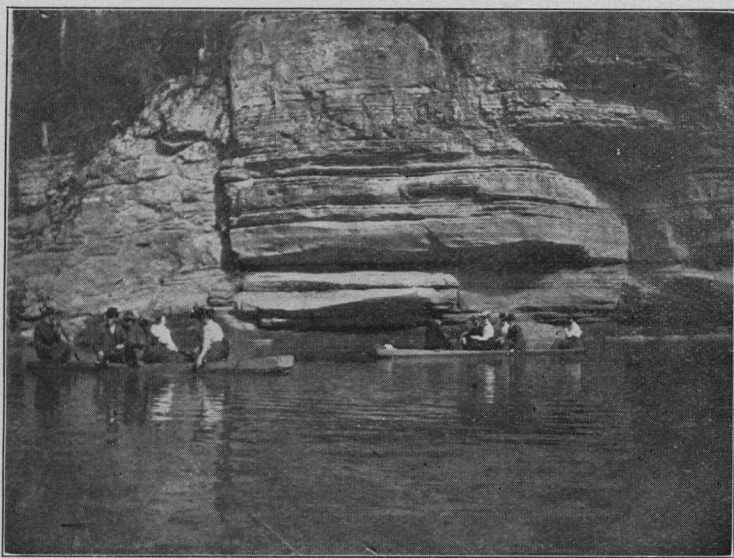
Thickness, 400 feet. Areal Outcrop, 80 square miles.

This formation, consisting mainly of massive limestones, has its best sections exposed in the gorge of the Kentucky river, where it trenches across the crest of the Cincinnati Geanticline in its stretch from Camp Nelson to Highbridge. It is naturally divided into three lithological divisions by a magnesian limestone horizon, the top of which is 90 feet below the top of the series. Linney, in describing these rocks for the reports of the former State Geological Survey, correlated the beds up to the base of the magnesian limestone with the Chazy of New York, and the remainder with the Birdseye of the same State.

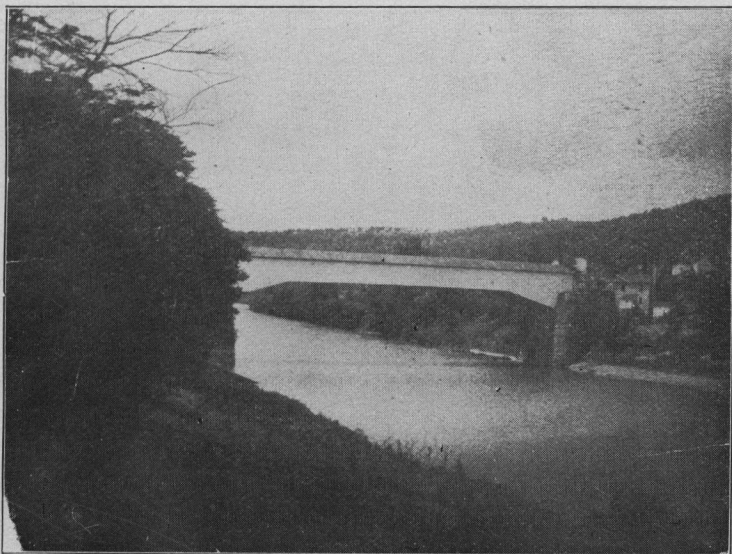
He assigned a thickness of 350 feet to his Chazy, 10 feet to the magnesian limestone, and 120 feet to the Birdseye. These figures are too great, except for the magnesian limestone.

For these three divisions we propose the locality names, Camp Nelson, Oregon and Tyrone—places along the Kentucky river at which good and typical sections of each are exposed. Camp Nelson, a Federal camp during the Civil War, and now a national cemetery, is situated on the Nicholasville and Danville pike, where it crosses the Kentucky river by a quaint old covered bridge. Oregon is a village in Woodford county, at the foot of the Versailles-Oregon pike; Lock No. 6 is about a mile below the village. Fine exposures of the magnesian limestone have been made here by the excavating operations incident to putting in the lock. Tyrone derives its name from the village in Anderson county, situated at the crossing of the Louisville Southern Railroad and Kentucky river. The magnesian limestone is here at water's edge, and fine exposures of the "Birdseye" are seen in the river cliffs and along the Versailles-Lawrenceburg pike, which crosses the river here.

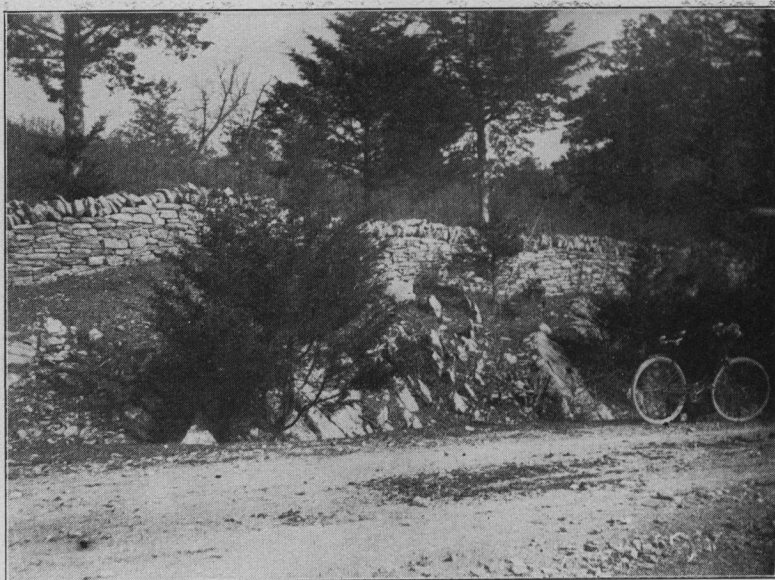
The outcrop of the Highbridge limestones of the Stone's



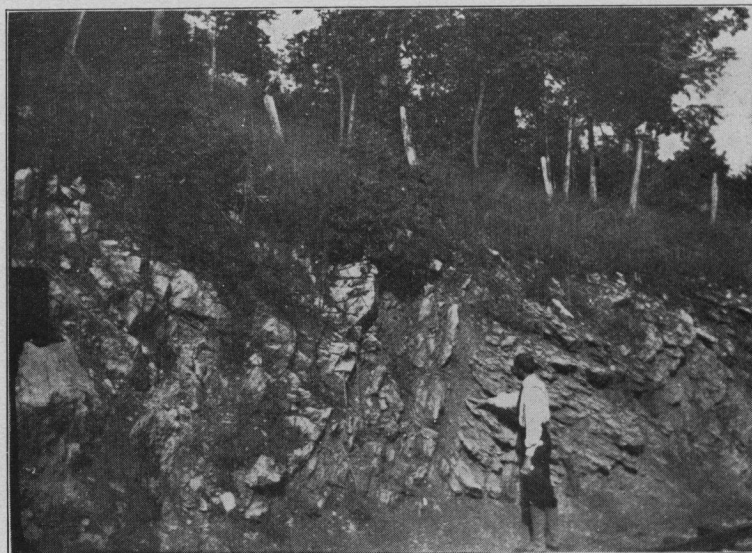
1. Small Fault in Camp Nelson Limestone, Kentucky River, Fayette Side,
Above Mouth of Elk Lick.



2. Oldest Rock Exposed in Kentucky. Camp Nelson Limestone at Foot of
Pier, Camp Nelson Bridge, Kentucky River.



3. Kentucky River Fault at Clay's Ferry, Showing Strike of Upturned Rocks on Down Throw Side.



4. Kentucky River Fault, Cut of L. & A. R. R., Near Marble Creek Trestle, Jessamine County, Kentucky.

River Series in Kentucky is confined to the immediate gorge of the Kentucky river and varying distances up its main tributaries in the stretch from Boonesboro (Madison county) to Johnson's Ferry, nine miles by river below Frankfort, Franklin county. The Highbridge limestones are much more resistant to atmospheric agencies than those which next succeed them in the series, and hence form much more precipitous cliffs along the streams. A very picturesque scenery attaches to the outcrop of this formation.

This characteristic is strikingly shown along the Kentucky river from Boonesboro to Camp Nelson. At the former place, the river strikes a fault—the Kentucky River Fault—turns from its northwesterly to a southwesterly course, and follows the fault as far as Camp Nelson, crossing it nine times in this distance. This means that for this stretch there are four meanders of the river lying on the northwest side of the fault and an equal number on the southeast side. As the downthrow of the fault is on the southeast side, the four northwest meanders are bedded in these hard Highbridge limestones and present steep imposing cliffs. The four southeast meanders are bedded in a formation in which shale and soft sandstones predominate and present retreating slopes wooded or cultivated to the river bank.

The meanders where breaks in the continuity of the Highbridge outcrop occur are: at Clay's Ferry (a small one); opposite the mouth of Jack's creek; opposite that of Tate's; and finally the "big bend" from a short distance before Valley View to the mouth of Little Hickman creek. Below this point to where the beds finally sink below drainage there are continuous exposures; and a precipitous cliff, as high as the formation is thick at that point, is found on one side of the river or the other.

All the main tributaries coming into the Kentucky river on the northwest side of the fault from Boonesboro to Johnson's Ferry, furnish good exposures of this formation.

On Boone's creek they reach a little above Morton's Mill;

on Marble creek, to the pike leading from Spears to Logana; on Hickman creek (in discontinuous patches on account of two faults, the Kentucky river and West Hickman creek) as far as Union Mills; on Jessamine creek, nearly to the crossing of the Nicholasville and Wilmore pike; on Dix river to a point east of Danville; on Clear creek across Woodford county to the Jessamine line just south of Troy. Below the mouth of Clear creek the formation has sunk so low in the river hills by reason of the northwest dip, that it soon passes below drainage in going up any of the tributaries.

In its whole outcrop this formation is included mainly between the 500 and 900-foot contours, reaching above the latter contour only in the vicinity of Camp Nelson and Sulphur Well (Ambrose), where the top is 920 feet above tide.

It is at these points alone that the formation gets out much upon the uplands and enters into the formation of soil. As might be expected from its resistant character, it is not much of a soil former. These soils are invariably thin and poor. The characteristic tree that follows the outcrop of the formation is the cedar.

CAMP NELSON BEDS. Typical locality, Camp Nelson, Jessamine county. The upper limit of this division of the High-bridge is the base of the Magnesian Limestone (Oregon); the lower limit is the oldest layers exposed at water's edge just below the old covered bridge at Camp Nelson. These are the oldest rocks seen in the State. Measured from level of river to the base of the Tyrone as seen exposed at top of river hill on the Nicholasville and Danville pike, the interval is 285 feet.

Excepting for some beds of whitish shale, not over three or four feet in thickness, the rocks are limestone—very massive and break with a conchoidal fracture. On fresh fracture, they exhibit a mottled appearance. On weathering, their edges become honeycombed, due to the dissolving out of replacements of a fossil. This fossil was originally a branching marine organ-

ism of uncertain affinities. It is the same fossil that gives the mottled appearance to fresh surfaces of the rock.

Other fossils are not abundant in the rock. Among bryozoans may be mentioned *Rhinidictya trentonensis* and *Phylloporina subluxa*; among brachiopods, *Scenidium anthonense*, *Rafinesquina minnesotensis*, *Strophomena incurvata* and *Dalmanella subaequata pervetus*; among gastropods *Lophospira perangulata* and *Macluria bigbyi* (the latter probably the most characteristic fossil of the formation); among cephalopods, various species of *Endoceras* and *Ormoceras* and at least one species of *Lituites*; among crustacea, an ostracod—*Leperditia fabulites*.

Much of the rock is well suited for building purposes, but its use is only local.

The top of this formation, where it reaches its highest level in outcrop is 800 feet above tide. This is in the vicinity of Camp Nelson village. In passing down the river from this point, the top sinks below drainage first at Lock No. 6. It is here at an elevation of about 500 feet, a drop of 300 feet in 17 miles, or a dip of about 17 feet per mile in a west 40 degrees north direction. Below Lock No. 6, the beds again show up at various points. Just below the dam at Lock No. 5, in the east bank, there is quite a fine exposure of the upper 23 feet, here quite fossiliferous. A short distance below here the beds finally pass from view beneath the river.

A number of caves occur in the Camp Nelson. The four best known are near Valley View, Camp Nelson, Glasses Mill and Highbridge, respectively.

OREGON BED ("Kentucky Marble" of Linney). Typical locality, Lock No. 6, near Oregon, southern Woodford county. Occurring very persistently, and with the same character in every outcrop, immediately above the Camp Nelson, are 25 to 30 feet of an even bedded limestone, the bottom and top of which are highly magnesian. Even the middle layers (only a few feet in thickness) exhibit streaks and partings of dolomite.

Some layers show marbled markings and have received the name "Kentucky River Marble," though the name has been applied to the whole bed, whether it has these markings or not. It would appear that Linney only recognized either the top or bottom layers as the "Magnesian Limestone," for he only assigned to it a thickness of 10 feet.

The rock is a fine building and ornamental stone. Freshly quarried, it is a light gray or cream color. On exposure, it acquires a yellowish tint. Its fracture is conchoidal. The layers run in even courses, some of them four feet thick. Some of these layers are durable and make fine abutment stone for bridges, etc. Despite this fact, it has not been used in the construction of the Government locks along the river (other than as common rock for rip-rapping), even though in the case of one of these locks (No. 6) it was so near at hand that it had to be blasted out of the way in the widening operations preliminary to the lock construction.

Formerly the stone was used more for building than it is at present. It has in the past entered into the construction of some historic structures. The Clay and Boone monuments in the Lexington and Frankfort cemeteries, respectively, are built of this stone, and also the pillars of the old State House at Frankfort. Old quarries, from which this stone was taken, may be seen at Grimes' Mill and Clay's Ferry in Fayette county, and there is a quarry in this formation at Highbridge from which bridge stone has been taken. No recognizable fossils have been found in this bed. In passing down the Kentucky river, the Oregon finally sinks from view in the vicinity of Clifton, Woodford county.

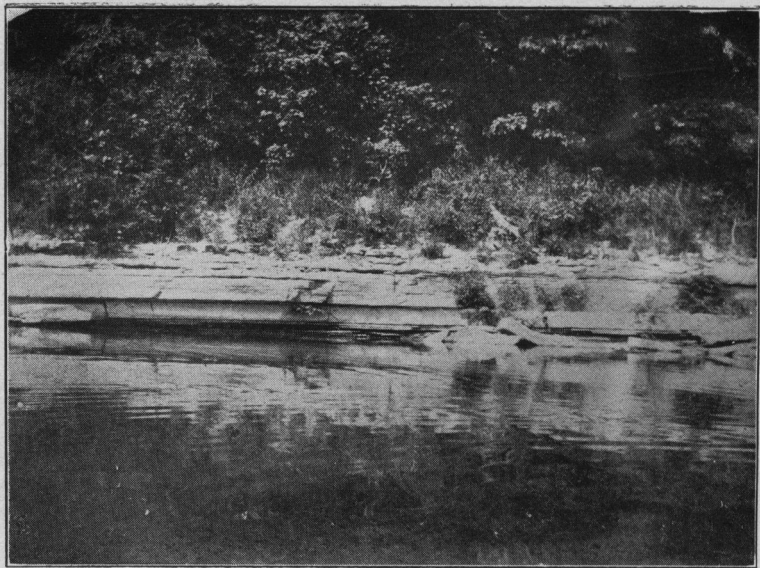
TYRONE BEDS ("Birdseye Limestone" of Linney).—Typical locality, vicinity of Tyrone, Anderson county. These beds occupy the next 90 feet in the scale. They are light or dove-colored limestones breaking with a conchoidal fracture, and exhibiting on the fresh faces of the rock calcite facets that have suggested the name "Birdseye" for this formation. A rock re-



5. Quarry in Oregon Bed (Magnesian Limestone), Near Clay's Ferry,
Fayette County, Kentucky.



6. Quarry in Oregon Bed (Magnesian Limestone), Near Glasses Mill,
Jessamine County, Kentucky.



7. Junction Between Oregon and Tyrone Limestone, Kentucky River, Near Tyrone.



8. Cedar Grove on Tyrone Limestone Soil, Near Watts' Mill, Jessamine County.

sembling this very much lithologically occurs at about the same horizon in as widely separated regions as New York, Tennessee and the Illinois-Wisconsin lead district. Its presence under much of the intervening territory has been established by the drill. It would appear therefore that we have in this formation a wonderfully persistent bed lithologically.

The facets which give such a characteristic appearance to fresh surfaces of the rock are cross sections of the replacement of some sort of marine fossil. This may have been either plant or animal, though it had a branching habit like a sea weed.

Beds of clay and clay shale occur through the formation. They vary in thickness from a few inches up to four feet. A rather remarkable bed of this kind near the top of the formation outcrops in the vicinity of Highbridge, Jessamine county, and at the same horizon crosses the river in Mercer. It is white with a greenish tinge, quite unctuous to the touch and fuses rather readily. This is probably due to the relatively high percentage of potash that it contains. It might make a good glaze or be used in tempering other clays in pottery manufacture. An analysis made in the laboratory of the State Agricultural Experiment Station gives the following as the composition of the clay:

Water	11.26
Silica (all combined).....	56.13
Potash	6.85
Soda .....	.44
Alumina and Oxide of Iron.....	23.79
Lime	1.03
Magnesia .....	.90

Fossils are not abundant throughout the Tyrone, but occasional layers, especially those that are shaly, are fairly fossiliferous. Some of the more common are:

Bryozoa: *Phyllodictya frondosa* and *Rhinidictya nichelsoni*.

Brachiopods: *Strophomena incurvata*, *Orthis tricenaria*, *Rafinesquina minnesotensis*.

Lamellibranchs: *Cyrtodonta huronense*.

Gastropods: *Hormotoma angustata*, *Helicotoma verticalis*.

Cephalopods: Several species of *Endoceras*, *Ormoceras* and *Orthoceras*.

Crustacea: *Leperditia fabulites*.

It will be noted that four of these fossils enumerated also occur in the underlying Camp Nelson. We have italicised these. *Orthis tricenaria* also occurs in the next succeeding formation. The "Birdseye Limestone" is a building stone of excellent quality and was formerly much used locally in construction of mills, distilleries and private dwellings. Many of these old structures may be seen in the deep gorges that usually mark the outcrop of this formation. The qualities of durability and beauty are such that the stone deserves to come into more general use. The rock tends to whiten on exposure.

We append an analysis of limestone from each of the three divisions of the Highbridge just described:

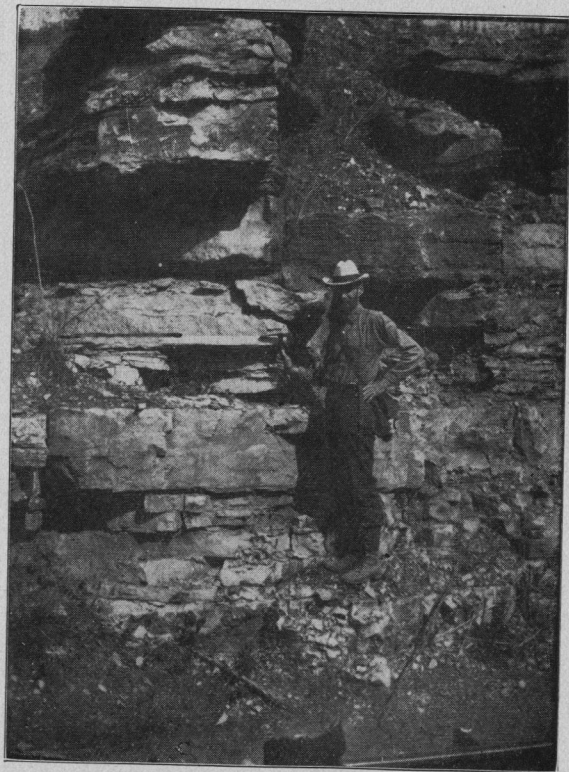
	Av. of 5 Specimens.		
	Camp Nelson.	Oregon.	Tyrone.
Lime carbonate	83.04	60.08	95.215
Magnesium carbonate	10.04	36.19	2.002
Alumina, Iron and Manganese Oxide .....	.98	.97	.505
Phosphoric acid .....	.....	.47	.091
Sulphuric acid (SO ₃) .....	.....	.436	.233
Potash .....	.....	.....	.207
Soda .....	.....	.805	.040
Silex and insoluble silicates .....	.....	.263	1.880
Water and loss .....	.....	.....	.....

Trenton.

Thickness 280 feet. Areal Outcrop about 1,480 square miles.

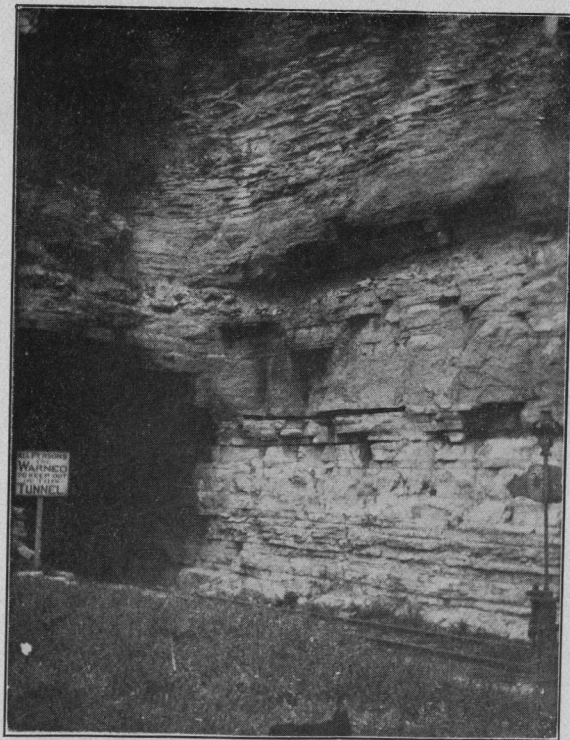
This, plus that of the Highbridge, was mapped with one color under the name "Trenton" on the State geological map, published under the supervision of Procter, in 1891. Considerable doubt has been expressed concerning the equivalence of much of the western Ordovician known as Trenton with the division in New York State which goes by that name.

We have retained the name for the series in Kentucky long known as Trenton, but have increased the scope somewhat by the addition of a bed about 40 feet thick taken from the base of what was formerly known as "Lower Hudson."



9.

Junction Between Tyrone and Curdsville Limestone, L. & A. R. R., Jessamine County, and L. & N. R. R. Tunnel. at Frankfort, Ky.



10

The Trenton outcrop in Kentucky (omitting reference to a few small "inliers" on the outskirts of the main area) forms two areas, the Central, or Bluegrass, and the Northern, or Ohio River. The former is central about the Jessamine Dome, where it succeeds to the Stone's River Series. It is the main area. The latter outcrops in the immediate valley of the Ohio river from about three miles above Higginsport to the vicinity of Warsaw, with a break in the continuity of the strip for a short distance below Cincinnati, where these beds sink below the level of the river.

The Bluegrass Trenton is mainly an upland formation, forming, except in the vicinity of the larger streams, a gently rolling topography with slopes not too steep for cultivation. Its outcrop forms the Bluegrass region par excellence of Kentucky. It forms the central part of an elevated peneplain, styled by Campbell the "Lexington Peneplain." It is thought that in tertiary time this whole region was eroded down to a nearly featureless plain lying almost at sea level; that subsequently it became elevated and perhaps bowed up in the process, though the main part of the "humping," forming the "Lexington Dome," may have been done previously. At present the surface of this plain lies mostly between 800 and 1,000 feet. Some points rise to 1,060, or perhaps even 1,100 feet. The top of the Lexington Limestone, formerly considered the top of the Trenton, reaches its greatest elevation in Jessamine county, where, near Brannon Station, the top is about 1,050 above tide.

Where it passes below drainage near Drennon Springs, in Henry county, the top is 430 feet above tide, a drop of 620 feet in this 50 miles, or a dip of 12.4 feet per mile in a north 34 degrees west direction.

SUBDIVISIONS OF THE TRENTON.

Campbell grouped all the limestones between the top of the Highbridge and the base of what he called the "Flannagan Chert" under the name "Lexington." Linney had previously

drawn his top of the Trenton at about this same horizon. Campbell's Lexington therefore is practically synonymous with Linney's Trenton. We retain the term Lexington in about the significance assigned to it by Campbell, except we make it also include the horizon of the Flannagan Chert for reasons assigned later.

The Lexington Limestone, as thus defined, admits of a division in Central Kentucky into four beds. In ascending order, these are Curdsville, Logana, Hermitage and Bigby. The first two names are of Kentucky origin, and are now proposed for the first time. Curdsville is a station on the Q. & C. R. R. in Mercer county. It is situated about five miles south of Highbridge. Logana is a station on the L. & A. R. R. in Jessamine county and is about three miles from the Kentucky river at Valley View. The other two divisions were established first by Ulrich in Tennessee and are named from localities in Tennessee. They do not seem to be as well differentiated in Kentucky as in Tennessee.

The remaining division of the Trenton, the Winchester, is a well marked division in the Bluegrass Trenton. It is not so well differentiated in the Ohio River Trenton. The section in this latter region is not deep enough to expose Logana and Curdsville horizons.

CURDSVILLE BED. Thickness 30 feet.—A very sharp lithological change takes place at the top of the Tyrone. The close-grained, sparingly fossiliferous limestone gives place without any transitions to a crystalline fossiliferous limestone. Although the change from the one to the other is so abrupt, there is no good evidence of an erosion interval having intervened between the deposition of the one and the other. And yet it would appear that we have here an unconformity of some kind—probably an interval during which no sedimentation took place.

The lower 15 feet of the Curdsville are cherty and richly fos-

siliferous. From the typical locality, Curdsville, a large number (many of them new species) have been described.

Some of the most characteristic are as follows:

Corals: *Streptelasma profundum*.

Crinoids: Stems and plates of *Hybocystites* sp?

Brachiopods: *Dinorthis pectinella*, *Orthis tricenaria*, *Rhynchotrema subtrigonale*, *Plectambonites* sp.?

Lamellibranchs.

LOGANA BED. Thickness 10 feet.—This bed in the typical locality, Logana Station, is composed of argillaceous limestone, very fossiliferous. This phase may be traced as a very persistent one through Jessamine and Woodford counties. In Franklin, shale predominates over the limestone.

The fossils are mostly molluscan. As abundant and in the main characteristic may be mentioned:

Lamellibranchs: *Modiolodon oviformis*.

Gastropods: *Protowartha pervoluta*, *Protowartha obesa*, *Liospira micula*, *Lophospira obliqua*.

The outcrop of the Curdsville and Logana will follow closely on a map that of the Tyrone, being usually a little further back from the brow of the cliff which the latter tends to form. The soil formed from the Curdsville and Logana is an improvement on anything any member of the Highbridge can furnish. A line of fairly copious springs usually follows the outcrop of the Logana.

In going down the Kentucky river, this bed sinks from view in the neighborhood of Harrod's Ferry, near the Franklin-Owen line, 18 miles by river below Frankfort.

HERMITAGE BEDS. Thickness 125 feet.—The rocks composing this division are grayish crystalline limestone with some shale. Some layers are slightly phosphatic.

The most abundant and characteristic fossil of these beds is a Bryozoan: *Prasopora simulatrix*. It is chocolate-drop like in form. Accompanying this in nearly every layer, the Brachiopod, *Dalmanella testudinaria*, is found. This latter

often completely covers the surfaces of the limestone slabs. We have now in ascending the series for the first time a truly upland formation. The soils formed on it are excellent.

BIGBY BEDS Thickness, 75 feet.—These beds consist of limestones similar in appearance to those of the Hermitage with which they imperceptibly merge. They incline to be a lighter gray than those of the Hermitage and are more phosphatic. This is especially so toward the top, where they also become cherty on weathering. They give rise to the very finest soils—constituting in fact the Bluegrass land “par excellence.” For this reason they may appropriately be termed the “Bluegrass Beds.” The two most characteristic fossils of the Bigby in Central Kentucky are the branchiopods *Hebertella borealis* and *Rhynchotrema inaequivalve*. In the Ohio River Trenton the latter has not been found, but the former has; and in the lowest beds in that region also *Prasopora simulatrix* and *Dalmanella testudinaria*, so it would appear that the Hermitage and Bigby horizons are recognizable there.

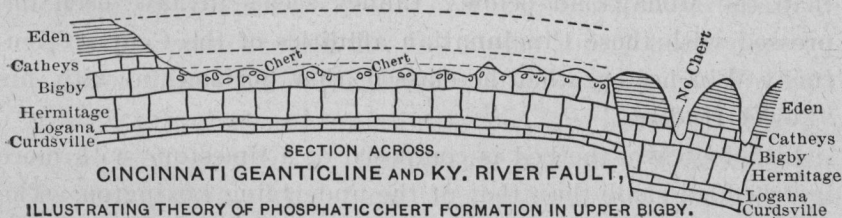
There is much more shale in the Ohio River Bigby than in the Bigby of Central Kentucky.

Near the base of the Bigby in a strip extending from Fayette through Scott into Franklin counties, there is a horizon at which a hydroid—*Stromatocerium pustulosum*—is very abundant. It forms large masses, hemispherical in shape, weighing often several hundred pounds. Near the top of this division of the Trenton in Kentucky occur two very characteristic fossils, a bryozoan, *Constellaria teres* and a coral, *Columnaria halli*. The latter fossil is very abundant as silicified masses in the deep red soil which results from the decomposition of these beds.

Forming the very top of the Bigby in many localities, and especially in the counties of Woodford and Franklin, is a “gastropod layer.” Here we frequently have massed in a ledge 4 to 5 feet thick nothing but gastropod shells belonging to *Bellerophon troosti* and *Lophospira medialis*. Wherever these upper

beds have been brought to the surface in broad areas under the slow process of atmospheric weathering, much chert has been developed in them and the fossils themselves are thoroughly silicified. This is also the principal phosphate horizon. The soil, leached limestone (in the form of thin plates) and even the chert itself, is highly phosphatic. This is the Flannagan Chert of Campbell. There is an objection, however, to making this a separate division of the Ordovician. It does not represent a constant time unit of deposition, but is rather due to a particular phase of weathering. The chert develops at this horizon only when unprotected by a very thick covering of superincumbent rock. In the deep cuts where this horizon is exposed south of the Kentucky Fault, as noted by Campbell himself, no chert is developed.

These facts and the interpretation suggested are set forth in the following figure:



The fossils of the Flannagan Chert are those of the Bigby, and hence we consider this chert as only a phase of the Upper Lexington due to weathering.

Another fossil which is found at this chert horizon, and is an invariable accompaniment of phosphate, is *Cyclora minuta*—an almost microscopic gastropod.

In western Woodford and in adjoining Anderson and to some extent in Franklin county, there is developed in the Lexington, about 60 feet above the base of the Bigby, an argillaceous limestone bed having a maximum thickness in one place of 29 feet. Above this comes in the same locality about 30 feet of granular phosphatic limestone. If this be added to the Lex-

ington, it gives for that stage in this region an unusually thick section. Fossils in both these argillaceous and overlying beds are not abundant. In the former *Asaphus gigas* and another undetermined trilobite, possibly *Proetus parviusculus*, and a lamellibranch (*Byssonychia*) are found. This rock has many of the lithological characters of beds higher in the series, and when by weathering they give rise to soils, these resemble those derived from the higher beds.

WINCHESTER BED. Thickness, 40 feet.—Ulrich makes the Tennessee equivalent of this, the Catheys, the top member of the Mohawkian Series, but does so mainly on structural grounds. In the Ohio river exposures, the sharper plane of division does take place at the top of what appears to correspond to the Winchester horizon, but in Central Kentucky the Winchester, lithologically as well as palaeontologically generally shows more affinity with the Cincinnati above than the Mohawkian below. Linney seems to have been impressed with these Cincinnati affinities of the Central Kentucky Winchester, when he classed this horizon in with his "Lower Hudson."

Lithologically the bed is composed of a limestone with more interbedded shale than that of the underlying Lexington. The limestones are also knottier and more coarsely crystalline. They are generally very fossiliferous. The most characteristic fossils in Kentucky, as in Tennessee, are a gastropod—*Cyclonema varicosum* and a bryozoan—*Heterotrypa parvulipora*. In some parts of Woodford and Franklin counties the upper 10 or 20 feet of the Winchester is a thin bedded granular limestone much like that of the Lexington below it. These beds are also phosphatic like the Lexington.

At the base of the formation is frequently a shale. At the same horizon in Woodford and Franklin counties frequently a few layers of a very hard limestone is developed, which is full of the ostracods *Isochilina jonesi* and *Leperditia josephana*, associated with the brachiopod *Orthorhynchula linneyi*. In

Mercer county at about the same horizon occur very compact limestones having pretty much the same lithological characters as the Tyrone much below them in the series. These were styled by Linney the "Upper Birdseye," a confusing term, as it is capable of two interpretations. This is also an ostracod bed, containing *Leperditia josephana* in abundance.

Other fossils of the Winchester in Central Kentucky are:

Hydroids: *Stromatocerium pustulosum*.

Corals: *Columnaria alveolata*.

Bryozoa: *Constellaria fisheri*.

Brachiopoda: *Hebertella*, like *sinuata*, but probably new species. *Platystrophia*, like *lynx*, but very small. *Zygospira modesta* and *Rafinesquina alternata*; abundant.

Cephalopoda: Various species of *Orthoceras*.

Lamellibranchiata: *Byssonychia*, like *radiata*.

Crustacea: *Asaphus gigas* and *Calymmene*, like *senaria*.

Take the fauna as a whole and it resembles very much that of the Lorraine at least 200 feet higher up in the series.

The soils of the Winchester, while good, on account of the greater prevalence of shale in the bed, are not so good as those of the Lexington below. As pasture lands the Winchester areas are unexcelled. This formation underlies in part the great cattle raising district of eastern Fayette, western Clark and southeastern Bourbon.

On the steeper slopes in the outskirts of the Bluegrass, where they occur with the Lexington below and the Eden above, they tend to slough off under the action of rain and frost much as the soil of the Eden does. This feature is also to be noted in railroad cuts where the sloughing off tends to fill the drainage ditches at the sides of the roads.

The outliers and peninsulas of blue within the Trenton area on the '91 State geological map represent, in so far as they are accurately laid down, mostly Winchester areas.

III.

THE MINERAL VEINS.

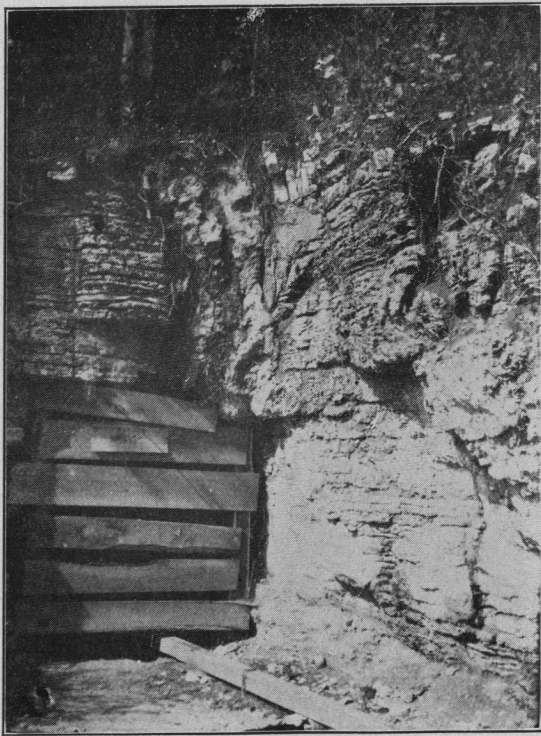
The outcrop of the Highbridge and Trenton in Kentucky is marked in some places by mineral veins. These have never been found extending up into the higher beds of the Ordovician.

The veins have been formed by the filling up of tension fissures which had been widened by the solvent action of water. The prevalence of shale in the Ordovician beds above the Trenton does not admit of the formation of open fissures in them. This seems to account for the cutting off of the veins at the top of the Trenton. They are wanting even in the Trenton, when this shows an abundance of shale as in the Ohio river outcrop.

There is no necessity for supposing that the veins were formed previous to the deposition of the Eden shale, as was suggested by Linney.

There is a difference between the veins of the Highbridge and those of the Trenton in the matter of vein content. Calcite and fluorite predominate as a veinstone in the former and barite in the latter. The latter are generally the richer in lead and zinc ores (galenite and sphalerite).

Though frequently found in association with faults, they are seldom in the faults themselves. Nearly all of them have a general north and south trend. Numerous attempts to work these veins in the past have not resulted in financial success to the promoters. This may perhaps be accounted for by the fact that the lead and zinc were the main objects of their search. No importance was attached to the barite and fluorite which accompanied the ores of the above-mentioned metals. It is not improbable that with a different object in view—the ob-



11. Fluorspar Vein in Tyrone Limestone, Faircloth's Ferry, Woodford County, Kentucky.



12. Barite—Galena Vein on Kentucky River, one mile below Gratz, Owen County.

taining of fluorite for fluxing purposes and barite for paint and enamels, and counting the lead and zinc only as by-products—these veins may yet be successfully exploited.*

In width these veins vary from mere streaks up to in one instance 24 feet. The usual width is from one to three feet. Each individual vein is apt to vary much in width from point to point, swelling or pinching as it is followed down or up or horizontally. They seem to have a considerable vertical extent. There are vertical exposures of veins in the cliffs of the Kentucky river for at least 200 feet, and mining operations have proceeded downward on some veins for depths varying from 100 to 325 feet. In no case has there been noticed any special tendency to close up.

In the detailed descriptions which follow, the veins are taken up by counties:

BOURBON COUNTY.

Paris Vein.—Yard of Daniel Isgrigg. Strike N. 30 degrees E. Dip of vein 10 degrees from the vertical in a northwest direction. The width of the surface is eight feet, measured from wall to wall. The filling consists of one foot of barite with sphalerite and galenite next to the northwest wall, with the other seven feet of a limestone breccia, cemented by galena and sphalerite. The vein may be traced for a distance of at least four hundred yards. The enclosing rock on the outcrop is Lexington limestone—Bigby division. Two shafts have been sunk on this vein, one to a depth of about one hundred feet.

— *The Cassius M. Clay Veins.*—There are some twenty of these on the land belonging to Mr. Clay, three miles southeast of Paris. The prevailing direction of strike is N. 40 degrees E. One of these veins can be traced for more than a mile. This one, at a place where a shaft was sunk upon it, is five feet wide. Like the Paris Vein, it is filled with breccia and barite along

*A detailed study of the veins with reference to their economic value has been undertaken. The results will be presented in another bulletin. Some of the veins promise well in metallic contents.—C. J. N.

with sphalerite and galenite. The barite band, sixteen inches wide, is on the southeast side. Another vein shows a width of thirty-five feet filled with breccia cemented with barite, galenite and sphalerite. They all break through Bigby Lexington limestone at the surface.

The Millersburg Veins.—These are in Lexington Limestone (Bigby division) and have a prevailing north and south trend.

HARRISON COUNTY.

The Lair Vein.—On the east side of the L. & N. R. R., three miles southeast of Cynthiana, is a vein of barite with some galena. It has been many years since prospecting has been done on this vein, and the thickness could not be determined. The strike is nearly north and south. The enclosing rock is the Bigby division of the Lexington.

The Hoggin Veins.—One mile south of Lair Station and on the west side of the L. & N. R. R. are two veins, only one of which is important enough to have led to any prospecting. It is sixteen inches wide at the surface and has a strike of N. 30 degrees W. The content is barite with galena through it in streaks. The enclosing rock is Bigby.

FAYETTE COUNTY.

Lexington, Potter's Field Vein.—On the old Potter's Field property and exposed in the railroad cuts of both the Belt Line and Louisville and Eastern R. R. This is a barite vein, having a width of about eighteen inches. The strike is nearly north and south and is certainly continuous along this line for several hundred yards. It seems to mark the presence of a slight fault, having Bigby limestone on one side and Catheys limestone and shale on the other.

Russell Cave Vein.—Not far from Russell Cave, about seven miles northeast of Lexington. This vein contains barite with galena. It was once worked for lead, and a shaft sunk on it

to a depth of about 200 feet. The enclosing rock is Lexington Limestone (Bigby and Hermitage).

The Dolan Vein.—On the Dolan farm, about seven miles northwest of Lexington. This is a small vein, not more than four inches in width. It contains barite with sphalerite. The latter makes quite a good showing.

Morton's Mill Veins.—There are two veins in this vicinity, only one of which is important. This one crosses Boone's creek about one mile above the mill. For a part of its outcrop where it crosses the creek, it is in the Tyrone formation; for the remainder it is in the Lexington. Its width varies from thirty-two to fifty inches. Its strike can be followed for about a mile in a direction almost due north and south. It dips to the west at an angle of 76 degrees. The veinstone is fluorite, calcite and barite. There are some traces of sphalerite present. The highest outcrop of the vein is on the Clark county side, where it reaches a point 240 feet above the creek. On the Fayette side, it reaches a height of 108 feet above the creek. Two shafts, one on the Clark and the other on the Fayette side, have been sunk on this vein. The Clark county shaft is about 100 feet deep. Both penetrate the Tyrone Limestone for some distance.

JESSAMINE COUNTY.

John West Vein.—On the farm of John West, about one mile northeast of Ambrose (Sulphur Well). The width of this vein where it is exposed in the road in front of the barn is twenty-four feet. It can be traced in outcrop five-eighths of a mile. The strike is N. 21 to 24 degrees W. The vein content shows only barite at the surface. No prospecting of any consequence has ever been done on this vein. It parallels two small faults that cross the road between it and Ambrose, and is cut off to the southeast by the Kentucky River Fault, which here has left the river and follows the course of Hickman creek. The enclosing rock at the surface is Bigby and Winchester.

Horine Vein.—Located just south of the village of Ambrose, on the north side of McKenna branch, near its source in the "Big Spring." The bottom of the gorge here is in the Oregon Bed, and the top in the Tyrone. The outcrop of the vein is diagonally up the steep slope and hence the strike is somewhat difficult to get, but it is about N. 34 degrees W. It is about twenty-five inches wide, and the vein content is fluorite and calcite with sphalerite. As judged by specimens picked up from the dump where the vein had been worked many years ago, this gangue is quite rich in zinc.

About one mile down the valley the Kentucky River Fault crosses this McKenna branch, and at this point there is in the zone of greatest slipping a barite vein eighteen inches wide. Other smaller veins occur in or near this fault in its course from here to where it strikes the Kentucky river at Camp Nelson, but they are unimportant.

GARRARD COUNTY.

A *barite vein*, two or three feet wide, crosses the Danville-Lancaster pike a little west of where the Kentucky River Fault crosses same. This is about four miles west of Lancaster.

MERCER COUNTY.

Green Million Vein.—On the Kentucky river, at the mouth of Shawnee Run. This vein begins to show in the river cliff just above the horizon of the Oregon Bed and 150 feet above the river and extends to the top of the vertical cliff, here about 100 feet high. The width of the vein is six to seven feet, and the strike is due north and south. The vein content is purest calcite—no sign of the presence of either lead or zinc. The Chinn Mining Company now owns this property.

Chinn Vein.—Around the bend of the Kentucky river, about one and one-half miles further down stream and so situated as to be almost due north of the Million Vein, is a vein about four feet wide composed of both calcite and fluorite with some

barite. The fluorite forms a band about two feet wide down the center of the vein, but divided at the middle by a seam. The calcite is in two bands each about one foot wide arranged on either side of the fluorite. The vein may be traced up the face of the very steep cliff to a point about 165 feet above the river. It is enclosed in all this distance by rocks of the Stone's River Series (Camp Nelson, Oregon and Tyrone). The strike seems to be about north and south.

The Chinn Mining Company has here erected an up-to-date mining plant and seems determined to make a thorough test of this vein. Beginning at a point thirty-seven feet above the river, the company has run an adit horizontally in on the vein eighty or one hundred feet, and at a point some distance from the inner end sunk a shaft on the vein to below the level of the river. The vein pinches and swells, but in the main preserves characters above described. No ores of any kind had yet been discovered in this vein, when we last visited it, but a consignment of calcite and fluorite was reported shipped to an Eastern firm. The fluorite in this vein appears to be of excellent quality. Magnificent specimens of this mineral, exhibiting very large cubical crystals, have been mined.

WOODFORD COUNTY.

The Faircloth's Ferry Veins.—There are two of these. One on Mr. Faircloth's place directly opposite the Million Vein at the mouth of Shawnee run. It can be seen in the rock at the side of the road leading up from the ferry. Its outcrop is here north 13 degrees west from the Million Vein. Its enclosing rock is here Tyrone Limestone. It can be traced up over the hill in a northerly direction from here into the Lexington Limestone. The vein is split in places. Where all the parts are together, they make a vein three feet wide. The content is fluorite. The other vein is almost back of Mr. Faircloth's house, near the ferry. This vein begins to show up in the cliff at the height of about 100 feet above the river, which is

here the horizon of the Oregon Bed. Sixty feet above this an adit has been run back on the vein for 150 feet. The vein shows up at the entrance three feet of nearly pure fluorite, much of it in the form of beautiful cubical crystals. Further in from the mouth of the opening the vein splits into two, and the fluorite aggregates only about one foot in width. The strike is N. 21 degrees E., as measured along this steep hill or cliff, side exposure. All these veins just described—those in Mercer as well as these in Woodford—are almost on the same line. It seems likely that this last Faircloth's Vein, just described, may be the same as the Chinn fluorite-calcite vein.

Shryock Ferry Vein.—About two miles above the ferry on the face of the steep cliff, which here consists of ninety feet of Tyrone, surmounted by 130 feet of Lexington. The vein extends from top to bottom. An adit has been run in on this vein at a point fifteen feet above the river. It extends back ninety feet. A vertical shaft has been sunk on the vein beginning at the top of the cliff. At the end of the adit, the vein is eighteen inches wide. The dip is vertical and the strike N. 5 degrees W. As long as the vein is in the Tyrone Limestone, its content is mainly calcite with some sphalerite; when in the Lexington Limestone, it is barite with little calcite or sphalerite.

These veins just described as occurring in the Kentucky river cliffs in the stretch from Brooklyn to Tyrone have no relation to faults. They seem to be simply fillings of tension cracks or fissures formed under strains insufficient to permit of faulting. The prevailing gangue is calcite and fluorite, and it will be noted that this seems to be the rule with the veins which traverse Highbridge Limestone. There are a few exceptions to this, but these veins are unimportant. One of these exceptions is the small vein on the Prewitt place—the

Prewitt Vein—situated in the river cliff about one and one-half miles below Brooklyn. It shows up two feet wide in the Tyrone Limestone, fifty feet above the base. It is mainly

barite, with a little fluorite at the contact with the walls. The strike of this vein is about due north and south.

On account of the almost universal association of the richer lead and zinc deposits of the world with magnesian limestone, wisdom would dictate that in hunting for the ores of these metals in the veins of the Kentucky River Limestones of the Highbridge Series, shafting should be done on these veins at the horizon of the Oregon Bed, because this is a highly magnesian limestone. No openings have been made at this level in any of these Woodford veins just described.

Shropshire Vein.—On the land of J. E. Shropshire, Mundy's Ferry road, fourteen miles from Versailles, 4.3 miles from Mundy's (Faircloth's) Ferry. This is a barite vein with some sphalerite. Its outcrop can be traced for a hundred yards or more and its width is about two feet. The enclosing rock is Lexington Limestone of the Hermitage division. A shaft has been sunk on this vein for a short distance. The strike is about 13 degrees west of north.

Withrow Vein.—On the Withrow place, about one mile west of Spring Station on the L. & N. R. R. The vein crosses the railroad. South of it an opening has been made on the vein by a vertical shaft about ten feet deep. The width of the vein is about two feet and the strike N. 14 degrees W. The content is barite with galena. There was quite a good showing of ore on the dump. The enclosing rock is Upper Lexington (Bigby) Limestone.

SCOTT COUNTY.

Johnson Vein.—On the hill overlooking McConnell's run, not far south of the Georgetown and Stamping Ground pike, and one and one-half miles from Duval Station on the Frankfort and Cincinnati R. R. The strike is N. 20 degrees E. The width is only six inches at the top, widening out into chambers as followed downward. From these chambers quite large masses of galena have been obtained. The gangue is barite.

The two shafts sunk to a distance of about 100 feet and connected at the bottom by a tunnel represent the amount of work done on this vein. The work is still in progress there and the lead is being smelted at Kissinger's. The enclosing rock at the top is Bigby. As is generally the case with lead-zinc veins, there is a notable increase in the percentage of zinc at the expense of the lead in this vein as it has been followed downward.

Hooke Vein.—On the farm of T. H. Hooke, about one mile east of Stamping Ground. This vein was opened some six or eight years ago and showed galena in a gangue of barite. The strike of the vein is N. about 12 degrees E. The enclosing rock is Winchester at the top, but most of the shaft must have been in the Lexington.

FRANKLIN COUNTY.

Jones' Vein.—About one and one-quarter miles south of Switzer. The strike of this vein is N. 7 degrees W. Enclosing rock at the top Winchester, with a few layers of Lower Eden Crinoidal Limestone. It has been so many years since this vein was worked that nothing could be made out in regard to the thickness or richness of this vein. It is reported, however, that some very large masses of lead were taken out. The gangue is barite. The land on which this vein is situated belongs at present to the widow of T. W. Jones.

Clark (Kissinger) Vein.—This vein has been opened up about three-quarters of a mile north of the Frankfort and Cincinnati R. R., at Kissinger's, which is very near the line between Scott and Franklin. A very extensive milling and smelting plant has been established at this point. The Clark Vein does not show up thicker than one foot at the surface, but, like the Johnson and other veins, widens out into chambers as followed downward. A long trench has been dug on this vein and two shafts sunk to the depths of forty and ninety feet, respectively. Some large masses of galena were removed from these chambers. The gangue is mainly barite, with some strontianite en-

crusting both the barite and the walls of the fissure. The strike is N. 13 to 15 degrees W. Following the vein in the line of the strike, it may be traced for something like a half-mile over onto the farm of E. Carter, where it appears to be cut off by a fault—the Kissinger Fault. This fault is the north one of two which together enclose a fault block strip extending in a northwesterly direction from Scott county, south of Stamping Ground, to the region just north of Peake's Mill in Franklin county. The Kissinger Fault has where it crosses the county a line of strike N. about 60 degrees W.

The fault bounding the strip on the south side passes just south of Switzer. The Jones and Clark Veins each bear about the same relation to these two faults; the one to the south and the other to the north of this strip. The enclosing rock of the Clark Vein is Winchester at the top, where it is exposed on the highest land, and Lexington Limestone (Bigby) lower down.

HENRY COUNTY.

Lockport Vein.—This vein is from one to two feet wide. Its strike is about due north and south. On the surface where it has been worked by an open trench for about 300 yards, it shows barite quite rich in galena—richer than any other vein yet examined in Central Kentucky. It is now owned by the Lockport Lead Mining Company, President H. G. Botts; Owenton; Superintendent J. H. Poteet, Lockport. The latter informed the writer that the company has mined 1,400 tons of ore. It has shipped 515 tons to Paducah, there to be concentrated. He said it averaged 20 per cent. galena.

This vein along the outcrop is in Upper Lexington (Bigby) Limestone. It has been traced across Six Mile creek and some distance southward. Northward it has been traced into continuity with the Gratz Vein to be next described.

OWEN COUNTY.

Gratz Vein.—One and one-half miles below Gratz on the river. The same vein as the Lockport has been opened by the Ohio Lead Mining Company—a company having its headquarters at Portsmouth, Ohio. The superintendent is M. H. Miller, Gratz, Kentucky. This company estimates the value of the mining plant and property at \$160,000. It is certainly the best equipped as regards mining and concentrating machinery of any mining company operating in Central Kentucky. It does no smelting, but ships all the concentrate to points outside of the State.

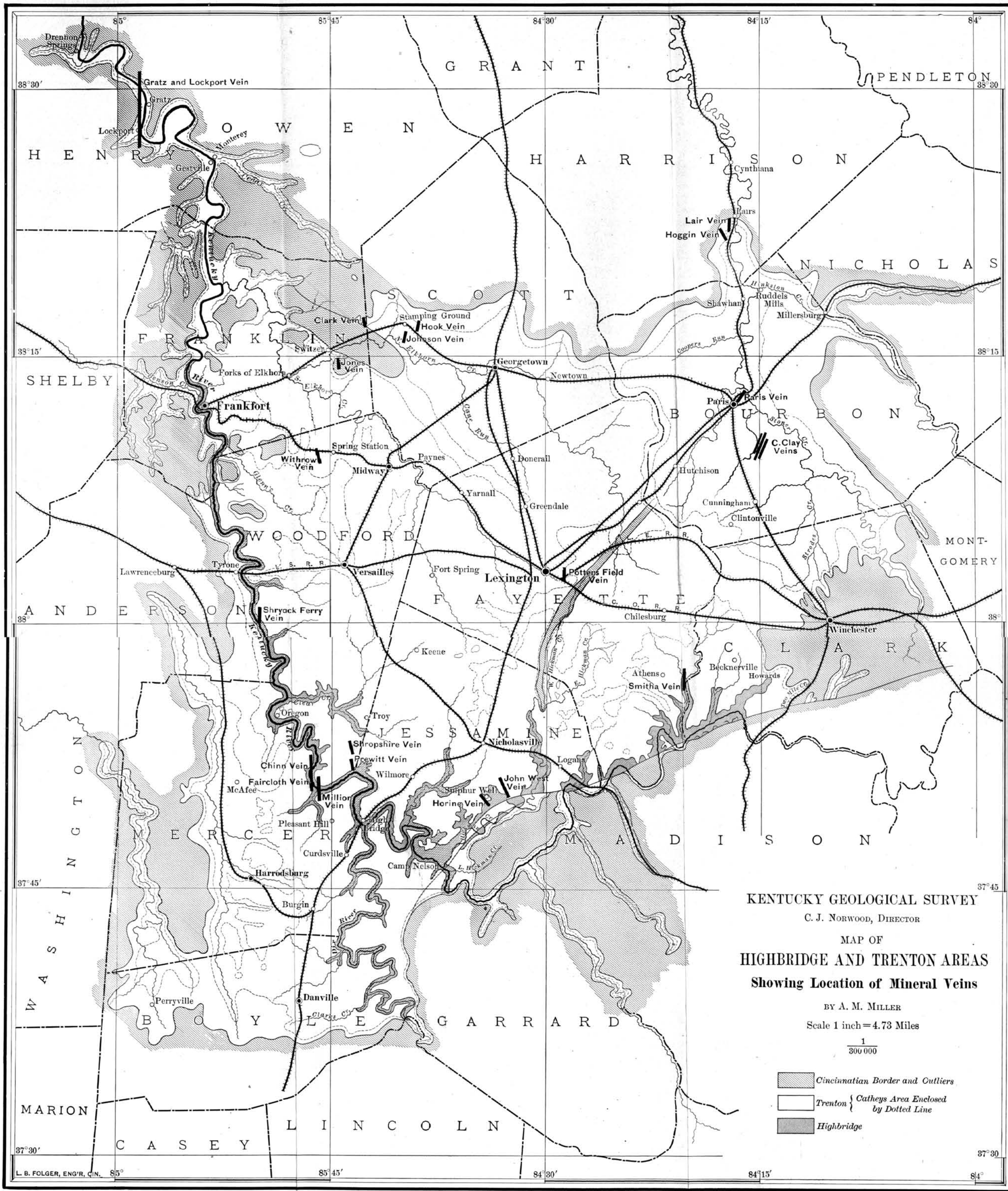
The vein has much the same characters as at Lockport, but the vein shows up poorer in barite and richer in calcite. The writer is informed by the superintendent that this is the way with the vein as it is followed downward. Below the two-hundred-foot level, measuring from the top of the shaft 140 feet above the river, the gangue is nearly pure calcite. It has the same geological relations as at Lockport, being enclosed in Lexington Limestone all along its outcrop. The top of the shaft, situated on top of the first bench in the river hill, is about fifteen feet below the top of the Trenton Limestone, and must be in the Catheys, but a covering of snow prevented the writer from positively establishing this fact when he made his visit to this locality. The vertical shaft in this mine descends to a depth of 325 feet. At 100 and 200 feet, adits are run out on the vein northward. The upper adit is 1,000 feet long to the northward; it is also extended southward and comes out on the surface in a tunnel, the mouth of which overlooks the river, forty feet below. Along these adit tunnels, the vein can be seen swelling and pinching and sometimes dividing. When it divides, the whole thickness, measuring from the outside streaks, is mined and concentrated. In these cases the rock itself contains disseminated lead. The levels below 200 feet were filled with water, when the visit was paid to

the mine by the writer, but the superintendent assures him that the vein shows no tendency to "play out" downward. It is also very persistent still further northward, having been traced for something like seven or eight miles in that direction.

At 300 feet, measuring from the top of the shaft, the "Birds-eye" limestone (Tyrone Formation) is reached. This gives an unusually thick section for the Trenton limestone, as the top of this formation is fifteen feet above the top of the shaft. It also gives data for estimating the dip of the Tyrone Formation in a north 21 degrees west direction for a distance of about fifty miles. The height of the top of the Tyrone at Camp Nelson is 920 feet above sea level. At Gratz it is 270 feet above the same datum line, a drop of 650 feet in these fifty miles, or thirteen feet per mile. This agrees pretty well with the rate of dip in the same direction for the top of the Lexington Limestone—12.4 feet per mile.

The present output of the Gratz mine is about fifty tons of ore per day. This yields on an average from the concentrating tables five to six tons of galena. No use has yet been made of the ground barite and zinc sulphide (sphalerite) which comes off the concentrating tables together. A considerable supply of this mixture has been accumulated at this mine, and should attract the attention of the lithophone manufacturing people.*

*Other Owen county veins and workings, such as those on Twin creek and neighboring regions, together with additional veins in Henry, Franklin and other counties, will be described in the bulletin hitherto referred to.—C. J. N.



KENTUCKY GEOLOGICAL SURVEY
C. J. NORWOOD, DIRECTOR
MAP OF
HIGHBRIDGE AND TRENTON AREAS
Showing Location of Mineral Veins

BY A. M. MILLER
Scale 1 inch = 4.73 Miles

$\frac{1}{300,000}$

- Cincinnatian Border and Outliers
- Trenton { Catheys Area Enclosed by Dotted Line
- Highbridge